BURROWING OWL CONSERVATION ON GOLF COURSES IN NORTH AMERICA

U.S. GOLF ASSOCIATION – WILDLIFE LINKS PROGRAM

FINAL REPORT – DECEMBER 2002

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Summary

Burrowing Owl populations appear to be declining throughout much of their range in North America, yet large-scale conservation programs to reverse declines are lacking. Burrowing Owls are attracted to golf courses because they prefer to nest and forage in open areas with short grass. Burrowing Owls rely on existing burrows in which to nest and limited burrow availability is thought to be one of the factors contributing to population declines. Golf courses within the range of Burrowing Owls could play a role in helping to restore local owl populations if nesting burrows were made available on suitable golf courses.

Our project was a pilot study to examine the efficacy of installing artificial nesting burrows on golf courses as a way to help restore Burrowing Owl populations. In 2000 and 2001 we installed 130 artificial nesting burrows on 8 golf courses and 87 artificial nesting burrows off golf courses to compare occupancy and reproductive success of artificial burrows on and off golf courses. Moreover, we located 575 natural burrows (175 with nests) to allow comparison of reproductive success between artificial burrows and natural burrows.

In 2001, 2 artificial burrows were used as nests (both of which successfully produced young), 1 burrow was occupied by an unpaired male, 3 burrows were used as roost burrows, and 3 burrows had signs of owl use. In 2002, 2 burrows were used as nests (both of which successfully produced young), 4 burrows were occupied by unpaired males, and 1 burrow had signs of owl use.

Although our sample size is small, nesting success was high for artificial burrows on golf courses (all 4 nests fledged ≥1 young). By comparison, nesting success varied from 61-77% for nests in natural burrows off golf courses, from 44-90% for nests in natural burrows on golf courses, and from 50-80% for nests in artificial burrows off golf courses.

Percent of artificial burrows on golf courses that were occupied by adult owls was low relative to other burrow types. However, the percent of artificial burrows in non-maintained areas on golf courses that were occupied by owls was similar to that of artificial burrows off golf courses (9%). In addition, the increase in the number of occupied artificial burrows on golf courses (3 in 2001 to 6 in 2002) demonstrates that owls are continuing to locate our artificial burrows on golf courses.

The number of adult owls using burrows, both natural and artificial, on our partner golf courses increased between 2000 and 2002. The proportion of owls occupying artificial burrows also increased between 2000 and 2002. Return rates (annual fidelity) of owls using burrows on golf courses were higher than the return rate for owls off golf courses. Owls used our artificial burrows only at the 2 golf courses that had Burrowing Owls nesting on golf course grounds at the outset of our project. We anticipate continued use of our artificial burrows over time with more of our artificial burrows being occupied by pairs and used as nest burrows in future years.

We measured a suite of landscape features at all 130 artificial burrows on golf courses in order to provide details to golf course superintendents regarding how and where to install artificial nesting burrows. All of the artificial burrows that were used by owls were in non-maintained areas (areas without regular mowing and watering) with the exception of one burrow occupied by an unpaired male in 2002. Burrows occupied by owls and nest burrows were closer to natural burrows than unoccupied burrows ($P = 0.02$ and $P = 0.03$, respectively). Occupied burrows were further from the nearest maintained areas and marginally further from the nearest sprinkler than unoccupied burrows ($P = 0.05$ and $P = 0.10$, respectively). No other differences

were found, however this is likely due to the small sample size of burrows used as nest burrows and occupied burrows (n = 4 and 8, respectively).

We recommend installing artificial burrows in non-maintained areas on golf courses that have nesting Burrowing Owls in the areas surrounding the golf course. In addition, we recommend that golf courses install artificial burrows at least 35 meters from the nearest maintained area and 45 meters from any sprinklers.

This study demonstrates that Burrowing Owls can successfully locate and use artificial nesting burrows in non-maintained areas on golf courses. The proportion of our artificial burrows occupied by owls was low (2% in 2001 and 5% in 2002), but the proportion occupied appears to be increasing as owls continue to locate these new burrows. In addition, nests in artificial burrows on golf courses successfully fledged young. Our project has received substantial positive media coverage and public interest. Two articles were published in *Golf Course News* (May 2000 and August 2002), an article in the local newspaper *The Tri-City Herald* (5 April 2000), a feature article in the *Seattle Times* (11 April 2000), an episode on the regional cable television show *Washington Wildlife* carried by 33 local cable stations, and a 10-minute story on the ABC news affiliate (KVEW) (July 2001). This media attention credited the U.S. Golf Association and the Wildlife Links program in particular. We have produced a pamphlet that can be distributed to superintendents and grounds crews at suitable golf courses within the range of Burrowing Owls to encourage participation in these conservation efforts. The pamphlet provides instructions for exactly how and where to install artificial nesting burrows on golf courses.

Golf courses typically lack the information or expertise to implement wildlife conservation efforts on their course. A well-publicized program that encourages many individual golf courses to contribute to a coordinated national effort could be particularly beneficial to wildlife conservation. The Burrowing Owl (*Athene cunicularia*) is an example of a species of local, regional, and national management concern that might benefit from coordinated conservation efforts on individual golf courses across North America.

Burrowing Owls in North America have suffered population declines and significant range contraction (Dechant et al. 1999). Burrowing Owls are a federal *Species of Conservation Concern* and are listed as endangered in Minnesota, Iowa, and Canada, and populations have declined significantly in Arizona, California, Colorado, Kansas, Nebraska, Nevada, New Mexico, Utah, and Washington (James and Espie 1997). Many state wildlife agencies are becoming increasingly concerned about declining owl populations. For example, Washington Department of Fish and Wildlife is currently evaluating the status of Burrowing Owls to determine whether they warrant state listing as threatened or endangered. Despite the widespread declines and increased concern for Burrowing Owl populations throughout North America, few conservation efforts exist to reverse population declines and prevent listing.

Because Burrowing Owls are still present in many areas throughout the western U.S. (Dechant et al. 1999), immediate implementation of effective on-the-ground conservation efforts is feasible and necessary to reverse declining population trends. Burrowing Owls require short-grass habitats and prefer open areas within deserts, grasslands, and shrub-steppe (Haug et al. 1993). Reduction of suitable nesting burrows (due to the eradication of burrowing mammals) is one cause of Burrowing Owl declines (Desmond and Savidge 1996). Hence, a widespread conservation program that provides artificial nesting burrows within short-grass habitats may help recover Burrowing Owl populations.

Golf courses have short-grass open areas that might provide suitable foraging areas for Burrowing Owls if artificial nesting burrows are made available. Indeed, Burrowing Owls are repeatedly seen foraging on golf courses throughout their North American range (Thomsen 1971). Mowing is thought to increase the attractiveness of nest sites for Burrowing Owls, and regular mowing throughout the nesting season does not appear to disturb nesting owls (Plumpton and Lutz 1993, Dechant et al. 1999). Artificial nesting burrows have been used successfully to augment nesting habitat in some local areas (Collins and Landry 1977, Trulio 1997) and may provide safer nest sites than natural burrows because artificial burrows are less susceptible to predation (Wellicome et al. 1997). Burrowing Owls appear tolerant of moderate levels of human activity and vehicle traffic because birds can easily retreat to the safety of their underground burrow. Hence, artificial nesting burrows on golf courses have the potential to help restore local Burrowing Owl populations.

Attracting Burrowing Owls to nest on golf courses may also provide benefits to the host golf courses. Burrowing Owls eat small rodents (mice, voles, pocket gophers) and invertebrates (grasshoppers, locusts, beetles, crickets, scorpions, earwigs) (Haug et al. 1993). Hence, owls may help control rodent populations and prevent periodic outbreaks of unwanted flying insects on golf courses (Marti 1974, Plumpton 1992). Moreover, resident Burrowing Owls may enhance the recreational value of a round of golf. Golfers typically enjoy viewing charismatic wildlife, and Burrowing Owls are unique among owls in that they are active throughout the daylight hours and are tolerant of moderate human activity. Finally, golf courses can gain positive local publicity by helping to reverse declining trends of a high-profile species of wildlife. If owls can

successfully reproduce in artificial nesting burrows installed directly on golf course grounds, the golf industry can increase the recreational value to golfers and simultaneously help conserve a sensitive wildlife species.

Our project was designed to evaluate the potential for golf courses across North America to contribute to Burrowing Owl conservation efforts. To evaluate the efficacy of artificial nesting burrows on golf courses, we compared occupancy and success between artificial burrows on and off golf courses. We developed partnerships with 8 golf courses in eastern Washington to help conduct our pilot study. We worked with the local Audubon Society, two National Wildlife Refuges (USFWS), Washington Department of Fish and Wildlife, private landowners, and other local community groups to help us install artificial nesting burrows on and off golf courses.

Project Partners

We brought together a large group of project partners on our Wildlife Links project. Partners included: U.S.G.A., Washington Department of Fish and Wildlife, Washington State University, Bureau of Land Management, U.S. Fish and Wildlife Service (Hanford Reach National Monument, McNary National Wildlife Refuge, and Columbia National Wildlife Refuge), National Fish and Wildlife Federation, U.S. Geological Survey, Arizona Cooperative Fish and Wildlife Research Unit, University of Arizona, Lower Columbia Basin Audubon Society, and 8 local golf courses. Golf Course partners included: Meadow Springs Golf and Country Club and Canyon Lakes Golf Course in Kennewick, WA, Sun Willows Golf Course in Pasco, WA, Buckskin Golf Course and West Richland Municipal Golf Course in West Richland, WA, Horn Rapids Golf Club and Columbia Point Golf Course in Richland, WA, and Moses Pointe Golf Course in Moses Lake, WA. Personnel working on the project included Dr. Courtney J. Conway, Matthew D. Smith, Lisa A. Ellis, Damon Hearne, Megan Hearne, Christopher Forristal, Gina Grasso, Gwyneth Balmer, Claire Sanders, Audrey Sanfacon, Sarah Millus, Todd McLaughlin, and Paul Ramey. Charlotte Reep (from the Lower Columbia Basin Audubon Society) was critical to the success of this project.

Artificial Burrows Installed on Golf Courses.

Between February of 2000 and August of 2001, we installed a total 130 artificial burrows on 8 golf courses in eastern Washington (Table 1). We installed artificial burrows in pairs and we varied burrow placement relative to maintenance levels and landscape features within a pair of burrows. For example, we installed one artificial burrow in an area under normal course maintenance (weekly mowing and daily irrigation), and the other in an area immediately adjacent to maintained areas that was not mowed or irrigated. We also installed some of the artificial burrows next to a tree (n=35), and other burrows out in the open (n=95) so that we could examine whether proximity to landscaped trees influenced whether owls would nest in artificial burrows on golf courses.

Artificial Burrows Installed off Golf Courses

We installed 87 artificial burrows off golf courses to compare occupancy and reproductive success with those installed on our partner golf courses. The local Audubon Society (coordinated by Charlotte Reep) worked with volunteers in the local community to install these burrows off golf courses.

Natural Nesting Burrows

We located and monitored 133 natural burrows in 2000, 186 in 2001, and 256 in 2002 in eastern Washington to compare annual burrow occupancy and reproductive success between artificial and natural burrows (Table 2). We also located and monitored 14 natural nest burrows that were on golf course grounds each year. Burrowing Owls typically nest in abandoned burrows of badgers, ground squirrels, or marmots.

Nest Monitoring

We visited all nesting burrows (artificial and natural) weekly throughout the breeding season to document occupancy and reproductive success. We first observed burrows from >100m away using binoculars to check for owl activity and then approached each burrow on foot to look for signs indicating use or vacancy (e.g., pellets, feathers, and presence of cobwebs at burrow entrance). During these weekly visits we recorded the stage of the nesting cycle, and number of adult and juvenile owls observed.

A burrow was considered occupied if 1 or more owls were present on 2 or more visits during the breeding season. A burrow was classified a nest if 2 owls were present on 2 or more visits during the breeding season. A nest was considered successful if $\geq$1 young owls were observed outside of the burrow on any visit. A burrow was classified as a roost burrow if it was used as an alternative burrow by an owl known to occupy another burrow as its primary burrow. Unpaired males that failed to attract a mate occupied some burrows.

In 2001 we used an infrared video probe to examine nest contents in a subset of our natural burrows. We randomly selected which burrows to examine with the video probe so that we could test whether use of the probe negatively affects nesting success of owls. A comparison of productivity between probed and non-probed nests revealed no negative effects of the probe, so the probe was used on all nests in 2002. Use of the probe allowed us to determine stage of the nesting cycle and numbers of eggs or juveniles present on each visit.

We implemented an "Adopt-A-Burrow" program in 2001 that involved local citizens interested in wildlife and Burrowing Owls. Participants in the "Adopt-A-Burrow" program agreed to monitor their assigned burrow weekly following our monitoring protocol. We had approximately 25 participants in this program who monitored artificial burrows for us.

Burrow Use and Nesting Success

Artificial burrows on golf courses: In 2000, none of the 99 artificial burrows installed on golf courses were used as nest burrows (most nests were initiated prior to burrow installation). Two burrows were used as roost burrows late in the year and 2 burrows had signs of owl use. In 2001, 2 burrows were used as nest burrows, both of which produced young. One burrow was occupied by an unpaired male, 3 burrows were used as roost burrows, and 3 burrows had signs of owl use. In 2002, 2 burrows were used as nest burrows, both of which produced young. Four burrows were occupied by unpaired males and one burrow had sign of owl use (Table 2). All of the artificial burrows used by owls were on 2 of the participating golf courses (Sun Willows Golf Course in Pasco, and Horn Rapids Golf Club in Richland). These 2 courses were the 2 courses that had owls nesting in natural burrows at the outset of our project.

Artificial burrows off golf courses: In 2000, 8 artificial burrows off golf courses were used as nest burrows, 4 of which produced young. Six burrows were used as roost burrows, 0 burrows were used by unpaired males, and 4 burrows had signs of owl use. In 2001, 6 burrows

were used as nest burrows, 3 of which produced young. Ten burrows were occupied by unpaired males and 7 burrows had signs of owl use. In 2002, 5 burrows were used as nest burrows, 4 of which produced young. Two burrows were occupied by unpaired males, and 1 burrow had signs of owl use (Table 2).

Natural burrows on golf courses: In 2000, 10 natural burrows on golf courses were used as nest burrows, 9 of which produced young. One burrow was occupied by an unpaired male, 1 burrow was used as a roost burrow and 1 burrow had signs of owl use. In 2001, 7 burrows were used as nest burrows, 6 of which produced young. Two burrows were occupied by unpaired males, 3 burrows were used as roost burrows and 1 burrow had signs of owl use. In 2002, 9 burrows were used as nest burrows, 4 of which successfully produced young. Three burrows were used as roost burrows and 1 burrow had signs of owl use (Table 2).

Natural burrows off golf courses: In 2000, 47 natural burrows off golf courses were used as nest burrows, 36 of which produced young. Fourteen burrows were occupied by unpaired males and 22 burrows were used as roost burrows. In 2001, 56 burrows were used as nest burrows, 39 of which successfully producing young. Fourteen burrows were occupied by unpaired males, 32 burrows were used as roost burrows and 18 burrows had signs of owl use. In 2002, 72 burrows were used as nest burrows, 44 of which produced young. Seventeen burrows were occupied by unpaired males, 33 burrows were used as roost burrows, and 4 had signs of owl use (Table 2).

Comparison of Burrow Use and Nesting Success

Percent of artificial burrows on golf courses that were occupied by adult owls was low relative to other burrow types. However, the percent of artificial burrows in non-maintained areas on golf courses that were occupied by owls was similar to that of artificial burrows off golf courses (9%). So, owls seem to avoid artificial burrows that are in maintained areas (in the rough) of golf courses. However, the proportion of artificial burrows in non-maintained areas on golf course that were used by owls was similar to that of artificial burrows off golf courses. In addition, the increase in the number of occupied artificial burrows on golf courses (3 in 2001 to 6 in 2002) demonstrates that owls are continuing to locate our artificial burrows on golf courses.

Natural burrows on golf courses were re-used as nests more frequently than other types of burrows (Table 2). The total number of adult owls using our partner golf courses appeared to increase during the course of our project, and the proportion of owls occupying artificial burrows also increased between 2000 and 2002 (Tables 3).

All four of the nests in artificial burrows on golf courses successfully produced young compared to 69% for nests in natural burrows off golf courses, 73% for nests in natural burrows on golf courses, and 60% for nests in artificial burrows off golf courses (Table 2). Nesting success (percent of nests that successfully produced young) was similar for burrows (both natural and artificial) on golf courses compared to those off golf courses (Table 2). However, the number of young produced per successful nest was lower for nests on golf courses (both natural and artificial) compared to those off golf courses in each of the past 3 years (Table 2).

Burrow Fidelity and Return Rate

We trapped and individually-marked owls to compare annual burrow fidelity between artificial and natural burrows. In 2000, we banded a total of 74 owls (6 adult males, 12 adult females, and 56 juveniles). In 2001, we banded a total of 300 owls (44 adult males, 47 adult

females, and 209 juveniles). In 2002, we banded a total of 280 owls (44 adult males, 38 adult females, and 198 juveniles).

Annual burrow fidelity was higher for owls on golf courses than for owls using burrows off golf courses in both of the past 2 years. In 2001, 2 females retuned to the same golf courses where they had occupied burrows in 2000. One of these females switched from a natural burrow to an artificial burrow and the other used a natural burrow both years. The female that switched from a natural burrow to an artificial burrow returned to the same golf course again in 2002 and nested in a different artificial burrow. Forty percent of the banded owls occupying a burrow on golf courses in 2000 returned to golf courses in 2001, whereas only 29% of the banded owls occupying a burrow off golf courses in 2000 returned to burrows off golf courses in 2001. Additionally, 1 male occupying a golf course burrow in 2000 returned to occupy a burrow off a golf course in 2001.

In 2002, 5 females and 3 males retuned to the same golf courses where they had occupied burrows in 2001. One of these females switched from a natural burrow to an artificial burrow, 2 used artificial burrows both years, and 2 used natural burrows both years. One of the males used an artificial burrow both years and 2 males used natural burrows both years. Sixty-nine percent of the banded owls occupying a burrow on golf courses in 2001 returned to golf courses in 2002, whereas only 36% of the banded owls occupying a burrow off golf courses in 2001 returned to burrows off golf courses in 2002. Additionally, 1 female occupying a golf course burrow in 2001 returned to occupy a burrow off a golf course in 2002 and 1 female occupying a burrow off a golf course in 2001 returned to occupy a burrow on a golf course in 2002.

Philopatry to breeding sites was higher for owls banded on golf courses than for owls banded off golf courses ($\chi^2 = 5.0$, df = 1, $P = 0.025$; data from all years pooled). The female that returned to the same golf course in 2001 and 2002 is one of only four banded owls on the entire study area to breed on this study area for 3 consecutive years. A bird returning to the same area to breed multiple years (high breeding philopatry) typically indicates a productive nesting habitat (Murphy 1996). As these owls frequently return to successful areas but breed in different burrows in these areas, we expect that the occupancy of artificial burrows will increase in the next few years.

Landscape Features Associated with Occupied Burrows on Golf Courses

In 2001, we measured a suite of landscape features at 128 of our artificial burrows on golf courses. These measurements allowed us to provide details to golf course superintendents regarding how and where to install artificial nesting burrows to achieve optimal success. Variables measured included whether the burrow was in a maintained or non-maintained area on the course, distance to the nearest maintained/non-maintained area, distance to the nearest cart path, distance to the nearest rough, distance to the nearest fairway, distance to the nearest sprinkler head, distance to the nearest green, distance to the nearest tee box, distance to the nearest tree, distance to the nearest natural burrow (occupied or unoccupied), and distance to the next nearest artificial burrow (occupied or unoccupied).

There was large variation in the landscape features associated with the artificial burrows that owls occupied (Table 4). However, all burrows used by owls were in non-maintained areas with the exception of one burrow occupied by an unpaired male in 2002. We used one-tailed *t*-tests to make comparisons of the means of landscape features associated with artificial burrows on golf courses: 1) we compared artificial burrows used as nest burrows with unoccupied

artificial burrows; and, 2) we compared occupied artificial burrows with unoccupied artificial burrows (Table 5). Burrows used as nest burrows and occupied burrows were closer to natural burrows than unoccupied burrows ($P = 0.03$ and $P = 0.02$, respectively). This result was not unexpected. Owls familiar with natural burrows in an area probably return to the same general area and then settle in a nearby artificial burrow. Occupied burrows were also further from the nearest maintained areas and marginally further from the nearest sprinkler than unoccupied burrows ($P = 0.05$ and $P = 0.10$, respectively). Owls seem to prefer burrows in areas of minimal golfer disturbance in areas where they don't get soaked by a nearby sprinkler. We failed to find any other differences, although we had a small sample of artificial burrows used as nest burrows and occupied burrows ($n = 4$ and 8, respectively).

Based on these results, we recommend that golf courses install artificial burrows in non-maintained areas with a minimum of 35 meters (100 feet) between the burrow and the nearest maintained area and 45 meters (150 feet) from any sprinklers.

Timing of Burrow Installation

To determine the optimal time of year to install artificial burrows, we recorded when adult owls typically return from migration. A small portion of the Washington population are year-round residents; some burrows have a single owl present throughout the winter. However, most of the population is migratory.

Of the natural burrows monitored weekly from 1 February – 1 October 2001, 17 were already occupied by males who presumably over-wintered. Mean arrival date for males at the other 31 nests was 16 March (range 15 February - 8 June). Most males (77%) were observed at their nest burrows by mid-March. Males appear to over-winter more frequently than females. Three females were seen at their nest burrow on our initial visit (1 February) and presumably over-wintered. Mean arrival date for the females at the other nests was 29 March. Most females (71%) arrived by 1 April.

The best time to install artificial burrows in areas where owls are already nesting might be after the owls migrate south for the winter, but prior to territory settlement (September through early February). This time frame may not always be feasible and local golf courses can always install artificial burrows in mid- or late summer in preparation for the following breeding season.

Burrow Installation Brochure

We developed an artificial burrow installation procedure that is relatively easy and produced a brochure with installation instructions that includes a list of required materials. The brochure is for superintendents and grounds crews at golf courses across North America so that they can install their own nesting burrows. An artificial nesting burrow consists of a 5-gallon (19-liter) plastic bucket or a larger Rubbermaid container buried upside-down (without the lid) 1.3 meters (4.25 feet) below ground. We use 3 meters (10 feet) of 10-centimeter (4-inch) corrugated drainage tubing to create a sloped tunnel leading from the ground surface down to the nest chamber. The 10-centimeter (4-inch) opening and a small patch of dirt are all that is visible after an artificial burrow is installed; golf course mowers can go right over the burrow entrance when necessary. An example of our brochure is enclosed.

Media Coverage and Public Relations

We received substantial media and press coverage of our Wildlife Links project. The local newspaper, the *Tri-City Herald*, did a front-page feature story on the project (5 April 2000). The *Seattle Times* also included a feature article on the project including a half-page full-frame picture of an owl on one of our partner golf courses (11 April 2000 issue). The *Seattle Times* article was included in a special feature highlighting great golf courses in the Northwestern U.S. A regional cable television show, *Washington Wildlife*, did an episode for their program on our project. The program was carried by 33 local cable television stations throughout Washington, Oregon, and Idaho. The piece explained the goals and objectives of the project and the unique partnership among the U.S.G.A., state and federal natural resource agencies, the local Audubon Society, the University, and local golf courses. The piece also included interviews with local golfers and the superintendent at one of our partner golf courses (Nick Rodrigues at Horn Rapids). We also were contacted by *Golf Course News* and asked to write an article for their magazine summarizing our Wildlife Links project; the article appeared in the May 2000 issue and was featured in an inset on the cover of that issue. The editor of *Golf Course News* visited our study site in 2002 resulting in a second article being published in the August 2002 issue. The local ABC news affiliate (KVEW) produced and aired a 10-minute story on our project in July 2001. The story featured artificial burrow construction on golf courses, owls using several of our constructed burrows as nests, and the future plans for the project. All of this media attention credited the U.S. Golf Association and the Wildlife Links program in particular.

This pilot project was a success because it demonstrated that Burrowing Owls can nest and produce offspring from artificial nesting burrows on golf courses. The proportion of our artificial burrows occupied by owls appears to be increasing as owls continue to locate these new burrows. In addition, annual fidelity of owls using burrows on golf courses was higher than owls using burrows off golf courses. We anticipate continued use of our artificial burrows over time with more of our artificial burrows being occupied by pairs and used as nest burrows in future years. Our project identified several landscape features associated with occupied burrows and developed an artificial burrow installation brochure to aid golf course superintendents in making decisions about where to install artificial burrows. Although the pilot program was a success, the 130 artificial burrows need to be monitored for several more years to fully evaluate their long-term effectiveness as a means to help restore local Burrowing Owl populations.

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Table 1. Distribution of the 130 artificial nesting burrows installed on 8 golf courses in eastern Washington.

	Partner Golf Course								
	Canyon Lakes	Columbia Point	Horn Rapids	Meadow Springs	Buckskin	West Richland	Sun Willows	Moses Pointe	**Total**
# of artificial burrows installed	19	10	30	7	8	8	30	18	130
# in maintained areas	16	10	12	7	4	5	13[2]	7	66
# in non-maintained areas	3	0	18[1]	0	4	3	17[3]	11	64
# close to a tree	2	3	6	2	4	4	8	6	35
# out in open	17	7	24	5	4	4	22	12	95

[1] 2 burrows used as nests in 2001 and one in 2002, 2 burrows used as roost burrows in 2001 and 1 in 2000
[2] 1 burrow used by an unpaired male in 2002
[3] 1 burrow used as a nest in 2002, 4 burrows used by an unpaired male in 2002 and 1 in 2001, 1 burrow used as a roost burrow in 2002, four in 2001, and 1 in 2000

Table 2. Occupancy and success of artificial and natural burrows both on and off golf courses in eastern Washington.

	2002				2001				2000			
	Artificial Burrows		Natural Burrows		Artificial Burrows		Natural Burrows		Artificial Burrows		Natural Burrows	
	on golf courses	off golf courses	on golf courses	off golf courses	on golf courses	off golf courses	on golf courses	off golf courses	on golf courses	off golf courses	on golf courses	off golf courses
Burrows present at start of current year	123	82	14	166	104	86	14	123	5	84	0	0
New burrows installed/discovered	0	0	0	90	26	1	0	63	99	2	14	133
Burrows monitored	123	82	14	256	130	86	14	186	104	86	14	133
Burrows destroyed	35	11	1	32	7	4	0	20	0	1	0	10
Burrows with an unpaired male (% of monitored burrows)	4 (3%)	2 (2%)	0 (0%)	17 (7%)	1 (1%)	10 (12%)	2 (14%)	14 (8%)	0 (0%)	0 (0%)	1 (7%)	14 (11%)
Burrows used as nest (% of monitored burrows)	2 (2%)	5 (6%)	9 (64%)	72 (28%)	2 (2%)	6 (7%)	7 (50%)	56 (30%)	0 (0%)	8 (9%)	10 (71%)	47 (35%)
Young/nesting attempt (mean ± SE) (*n*)	2.0 ± 0.0 (2)	2.6 ± 1.2 (5)	0.9 ± 0.4 (9)	0.2 ± 0.2 (72)	2.5 ± 1.5 (2)	2.3 ± 1.4 (6)	2.3 ± 0.7 (7)	2.7 ± 0.3 (56)		0.9 ± 0.5 (8)	2.6 ± 0.4 (10)	2.2 ± 0.3 (47)
Nests that were successful (% of nests)	2 (100%)	4 (80%)	4 (44%)	44 (61%)	2 (100%)	3 (50%)	6 (86%)	39 (70%)		4 (50%)	9 (90%)	36 (77%)
Young/successful nest (mean ± SE) (*n*)	2.0 ± 0 (2)	3.3 ± 1.3 (4)	2.0 ± 0.8 (4)	3.7 ± 0.3 (44)	2.5 ± 1.5 (2)	4.7 ± 2.0 (3)	2.7 ± 0.8 (6)	3.9 ± 0.3 (39)		2.3 ± 0.8 (4)	2.6 ± 0.4 (9)	3.0± 0.3 (36)

Table 3. Number and relative percentage of owls on our partner golf courses that used artificial burrows.

	2002		2001		2000	
	Artificial	Natural	Artificial	Natural	Artificial	Natural
# of burrows with unpaired male	4	0	1	2	0	1
# of burrows with nest (2 owls/burrow)	2	9	2	7	0	10
Total # of adult owls	8	18	5	16	0	21
Total resident owls on golf courses	26		21		21	
Percent of golf course owls using artificial burrows	31%		24%		0%	

Table 4. Landscape features (mean ± SE) associated with artificial burrows on golf courses comparing differences between nest burrows, occupied burrows, and unoccupied burrows.

Landscape feature (m)	Artificial burrows used as nests (*n*=4)	Occupied artificial burrows (*n*=8)	Unoccupied artificial burrows (*n*=120)
Distance to maintained area	48 ± 24	33 ± 13	18 ± 3*
Distance to cart path	55 ± 33	39 ± 16	41 ± 3**
Distance to rough	57 ± 33	34 ± 18	151 ± 2
Distance to fairway	74 ± 34	47 ± 19	34 ± 3
Distance to sprinkler	60 ± 26	43 ± 14	23 ± 2
Distance to green	106 ± 31	98 ± 17	104 ± 6
Distance to tee box	88 ± 33	90 ± 23	82 ± 6
Distance to tree	14 ± 5	21 ± 5	17 ± 1
Distance to nearest natural burrow	149 ± 68	180 ± 43	290 ± 20***
Distance to next nearest artificial burrow	72 ± 26	57 ± 15	45 ± 4****

*n = 57
**n = 116
***n = 52
****n = 119

Table 5. Results of *t*-tests comparing the means of landscape features associated with artificial burrows on golf courses used as nest burrows vs unoccupied burrows, and occupied burrows vs unoccupied burrows.

	Burrows used as nests vs. unoccupied burrows			Occupied burrows vs. unoccuiped burrows		
Landscape feature	*t*	*df*	*P*	*t*	*df*	*P*
Distance to maintained area	-1.21	3.01	0.16	-1.61	63	**0.05**
Distance to cart path	0.91	118	0.18	-0.15	122	0.44
Distance to rough	1.26	3.03	0.15	1.07	7.22	0.16
Distance to fairway	1.12	3.04	0.17	1.06	126	0.15
Distance to sprinkler	1.40	3.02	0.13	1.40	7.18	0.10
Distance to green	0.62	122	0.48	-0.24	126	0.41
Distance to tee box	0.2	122	0.42	0.35	126	0.36
Distance to tree	-0.37	122	0.36	0.70	126	0.24
Distance to nearest natural burrow	-1.93	54	**0.03**	-2.08	58	**0.02**
Distance to next nearest artificial burrow	1.28	121	0.10	0.82	125	0.21

150 words

Burrowing Owl populations are declining throughout much of their range. Limited burrow availability is considered a factor contributing to declines because Burrowing Owls use abandoned burrows created by fossorial mammals. Burrowing Owls are attracted to golf courses because they prefer to nest and forage in open areas with short grasses. Nesting owls can benefit golf courses by consuming pest species (rodents and invertebrates) as well as providing wildlife viewing for golfers. We installed 130 artificial nesting burrows on golf courses in eastern Washington. Owls located and used some of our artificial burrows for nesting. All 4 of the artificial burrows that were used as nests successfully fledged young. Golf courses within the North American range of Burrowing Owls may be able to play a role in helping to restore local owl populations by installing artificial nesting burrows on their courses.